■ Interagency Ecological Program for the San Francisco Estuary ■

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decreased slightly in 2010. Fall 2010 abundance increased from 2009, and was the highest fall abundance recorded. In 2010, *A. macropsis* was most abundant from January through April and again in December in San Pablo Bay and Carquinez Strait; by November and December *A. macropsis* distribution shifted upstream and was most abundant in eastern Suisun Bay. The highest CPUE of 2010 occurred in February in eastern San Pablo Bay and Carquinez Strait where the average abundance was 18 m^{-3}.

References:

Bouley, P. and W.J. Kimmerer. 2006. Ecology of a highly abundant, introduced cyclopoid copepod in a temperate estuary. Marine Ecology Progress Series. 324: 219-228.

Brown,T. 2009. Phytoplankton Community Composition: The Rise of the Flagellates. IEP Newsletter 22(3):20-28.

2010 Status and Trends Report for Pelagic Fishes of the Upper San Francisco Estuary

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Introduction

The 2010 Status and Trends report includes pelagic fish data from 4 of the Interagency Ecological Program's long-term monitoring surveys in the upper San Francisco Estuary: 1) the Summer Townet Survey (TNS), 2) the Fall Midwater Trawl Survey (FMWT), 3) the Delta Smelt 20mm Survey (20mm Survey), and 4) the U.S. Fish and Wildlife Service (USFWS) Beach Seine Survey (see Honey et al. 2004 for additional information). The most recent abundance indices, long-term abundance trends, and distributional information are presented by species phylogenetically in following sections for American shad (*Alosa sapidissima)*, threadfin shad (*Dorosoma petenense*), delta smelt (*Hypomesus transpacificus*), longfin smelt (*Spirinchus thaleichthys*), wakasagi (*H. nipponensis*), splittail (*Pogonichthys macrolepidotus*) and striped bass (*Morone saxatilis*). Several of these pelagic species that spawn and rear in the upper estuary have undergone severe declines in recent years (Sommer et al. 2007). To date, the abundances of POD fishes persist at very low levels.

Abundance indices and distribution of upper estuary demersal fishes and marine demersal and pelagic fishes will be reported in an upcoming IEP Newsletter.

Methods

Freshwater flow through the estuary positively affects the abundance of many upper estuary fish species (Stevens and Miller 1983, Jassby et al. 1995, Kimmerer 2002). We examined outflow effects by regressing species annual abundance indices on a mean outflow measure derived by grouping flow data from a critical seasonal period in each species' life. Though the actual mechanism(s) for these relationships remain unknown, it is believed that increased outflow enhances abundance by one or more of several mechanisms: 1) increasing low salinity habitat; 2) by dispersing and transporting larvae or juveniles to favorable habitat; 3) by stimulating the food web and increasing food supply; or 4) by reducing predation or other top down effects. Delta outflow data, as daily outflow in cubic feet per second (cfs) at Chipps Island, were acquired from the Department of Water Resources Dayflow database available online at: http://www.water.ca.gov/dayflow/. Daily outflow values were averaged by month, then averaged again for a series of months specific to each fish species representing an important period. In most cases, these outflow means were $\log_{10}$ transformed, and then $\log_{10}$ transformed abundance indices were regressed on the transformed outflow means and plotted. These abundance vs. outflow plots distinguish years leading up to the establishment of *Corbula amurensis* in the estuary (i.e., through 1987), years after establishment (1988 and later) and years after the start of the pelagic organism decline (i.e., POD, i.e., after 2000) to depict how the relationships have changed.

The 20mm Survey monitors larval and juvenile delta smelt distribution and relative abundance throughout its historical spring range, which includes the entire Delta downstream to eastern San Pablo Bay and the Napa River. Surveys have been conducted every other week from early March through early July since 1995, with 9 surveys com-

1. Authorship: Introduction and methods, K. Hieb, S. Slater and Randy Baxter; American and threadfin shad, longfin smelt, and wakasagi, D. Contreras; delta smelt, splittail, and striped bass, V. Afentoulis; and splittail introduction, R. Baxter.

pleted in 2010. Three tows are completed at each of the 48 stations (Figure 1) using a 1,600-µm mesh net (Dege and Brown 2004). Five Napa River stations were added in 1996 and 2 stations each were added in Lindsey Slough, Miner Slough, and the SDWSC in 2008. The survey name is derived from the size (20 mm) at which delta smelt are readily identifiable and counted at the State Water Project and Central Valley Project fish facilities.

The TNS has been conducted annually since 1959, and its data has been used to calculate age-0 striped bass indices for all years except 1966, 1983, 1995 and 2002. In addition, age-0 delta smelt indices have been calculated for the period of record, except for 1966-1968. The TNS currently begins in June and samples 32 historic sites from eastern San Pablo Bay to Rio Vista on the Sacramento River and Stockton on the San Joaquin River (Figure 2). Historically, the number of surveys completed per year ranged from 2 to 5 depending upon how fast striped bass grew past the 38.1 mm length; beginning in 2003, sampling was standardized to 6 surveys per year, starting in early June and running every other week through August. Beginning in 2011, the TNS will add 8 stations in the Cache Slough, Sacramento Deepwater Ship Channel (SDWSC) regions to increase spatial coverage and better detect the range and habitat of delta smelt (Figure 2). At least 2 tows are completed at each station and a third tow is conducted if any fish were caught during the first 2 tows. The annual striped bass index is calculated as an interpolation between the 2 survey indices that bracket when age-0 striped bass reach or surpass a mean 38.1 mm fork length (FL) (Chadwick 1964, Turner and Chadwick 1972). The delta smelt annual index is the average of the first 2 survey abundance indices of each survey year.

The FMWT has sampled annually since 1967, except 1974 and 1979, when no surveys were conducted, and 1976, when sampling was limited and indices were not calculated. The FMWT survey was initiated to determine the relative abundance and distribution of age-0 striped bass in the estuary, and subsequently develop the same information for other upper-estuary pelagic species, including American shad, threadfin shad, delta smelt, longfin smelt, and splittail. The FMWT survey samples 122 stations monthly from September to December in an area ranging from San Pablo Bay to Hood on the Sacramento River, and to Stockton on the San Joaquin River (Figure 3). The index calculation (see Stevens 1977) uses catch data from 100 of the 122 stations; the remaining 22 stations were added over time in 1990, 1991, 2009, and 2010 to enhance our understanding of delta smelt habitat use (Figure 3).

USFWS has conducted beach seine sampling weekly since 1994 at approximately 40 stations in the Delta and the Sacramento and San Joaquin rivers upstream of the Delta (Brandes and McLain 2001, Honey et al. 2004). These 40 stations range from Sherman Lake at the confluence of the Sacramento and San Joaquin rivers upstream to Ord Bend on the Sacramento River, and to just downstream of the Tuolumne River confluence on the San Joaquin River. Catch per haul data from these stations were used to calculate the annual age-0 splittail abundance index. Stations were grouped into 10 regions (5 within the Delta, 3 upstream in the Sacramento River and 2 upstream in the San Joaquin River) and the annual index was calculated as the sum of regional mean catch per seine haul for May and June sampling. Regions were grouped into 3 categories -- the Delta, Sacramento River and San Joaquin River – for graphical presentation and to recognize regional contributions to the overall index.

We used data sets from the TNS and FMWT surveys to describe abundance trends and distribution patterns of upper estuary pelagic fishes listed in the introduction. Two data sets provided only single species indices: the 20mm Survey data for a combined larval and small juvenile delta smelt index and the USFWS beach seine data for age-0 splittail index. Catch-per-unit-effort (CPUE), reported as catch per tow, was consistently used to analyze and report distribution.

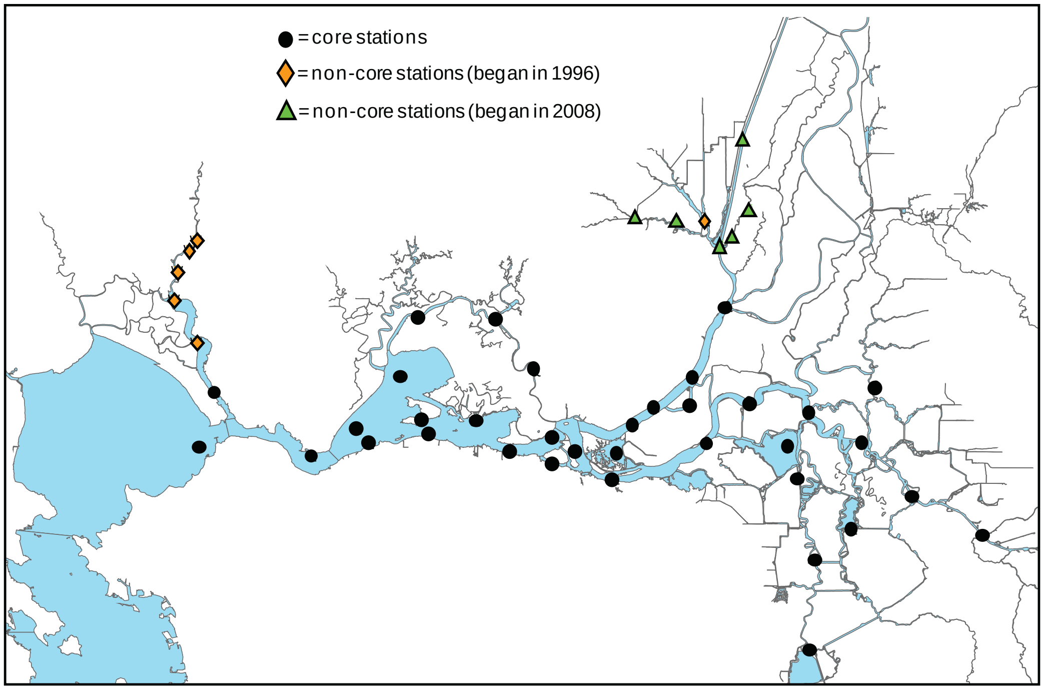

Figure 1 20mm Survey station map.

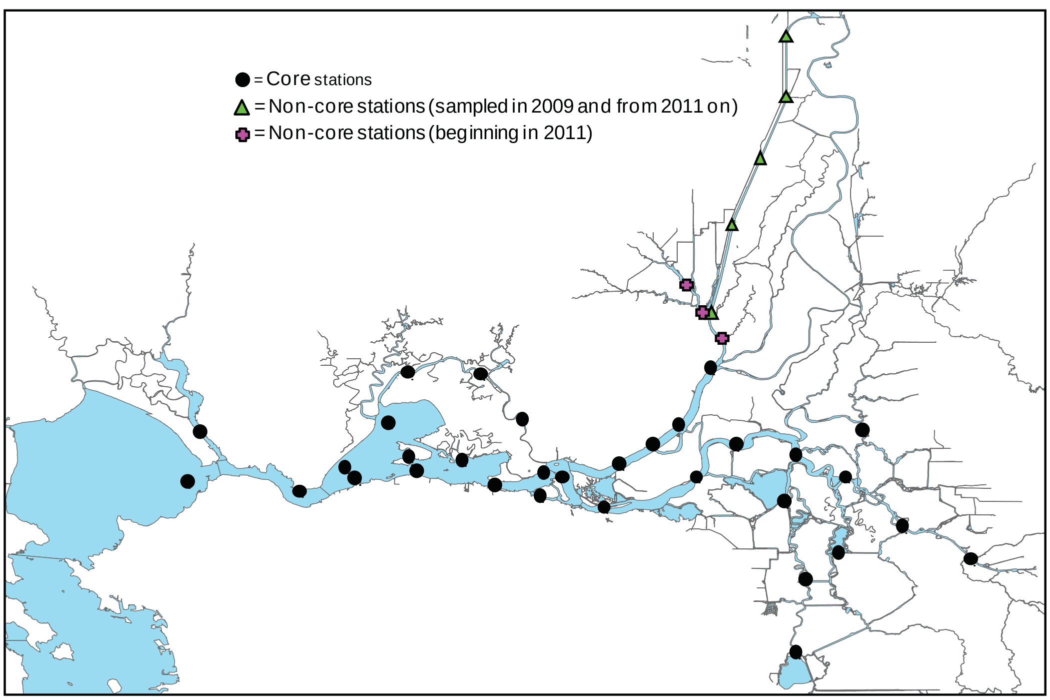

Figure 2 Summer Townet Survey station map

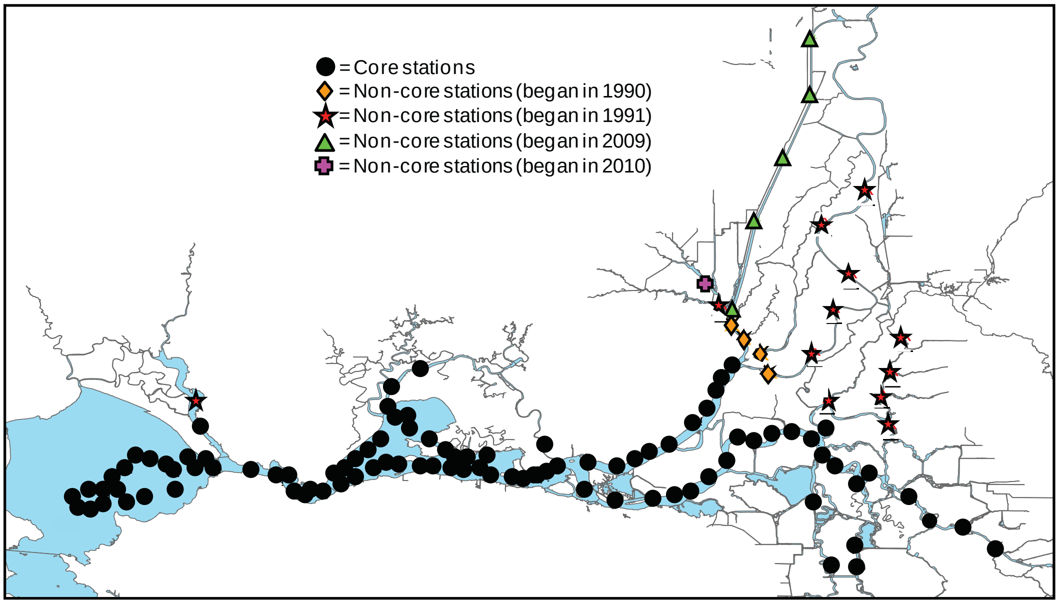

Figure 3 Fall Midwater Trawl Survey station map.

American shad

The American shad was introduced into the Sacramento River in 1871 (Dill and Cordone 1997) and is now found throughout the estuary. This anadromous species spawns in rivers in late spring, rears in fresh water through summer (including the Delta starting in late May), and migrates to the ocean in late summer and fall. It spends approximately 3 to 5 years maturing in the ocean before returning to freshwater to spawn. Most males reach maturity within 3 to 4 years of age, while most females reach maturity within 4 to 5 years of age. Spawning occurs in the Sacramento, Feather, and American rivers from April through June, after which a large percentage of adults die (Stevens 1966). All life stages of American shad are planktivores.

The 2010 FMWT American shad (all ages) index was slightly higher than the 2009 index, and the sixth lowest index on record (Figure 4). With the exception of the record high index occurring in 2003, indices have been below the study-period mean since 1998. American shad were collected in all areas of the upper estuary in 2010, but were most common from the lower Sacramento River downstream through Suisun Bay. The patterns of catches over time reflected out migration as they were most common in the lower Sacramento River in September and October, the SDWSC through Suisun Bay in November, and Suisun Bay through San Pablo Bay in December.

The American shad index increased from 2009 to 2010; however abundance remained relatively low, which may have resulted from the moderately low spring outflow in 2010. American shad abundance has shown a positive correlation with delta outflow during the spring spawning and early rearing period, April through June (Figure 5; Stevens and Miller 1983). For unknown reasons this response was enhanced after the introduction of the overbite clam, *Corbula amurensis*, in the late 1980s (Kimmerer 2002). During the POD years (2001-2010) abundance was more variable and the outflow-abundance relationship became steeper (Figure 5). After 2004, the American shad abundances were lower than expected for the given flows.

Threadfin Shad

Threadfin shad was introduced into reservoirs in the Sacramento-San Joaquin watershed in the late 1950s and quickly became established in the Delta. Although it is found throughout the estuary, it prefers oligohaline to freshwater dead-end sloughs and other low-velocity areas

(Wang 1986). It is planktivorous its entire life, feeding on zooplankton and algae (Holanov and Tash 1978). Threadfin shad may reach maturity at the end of their first year and live up to 4 years. Spawning occurs in late spring and summer and peaks from May to July (Wang 1986).

The 2010 FMWT threadfin shad (all ages) index was 2.8 times the 2009 index (Figure 6) and the second lowest index on record. Since 2002, threadfin shad abundance has been below the study period mean, but showed a slight increasing trend through 2007 before dropping off precipitously. Threadfin shad in September and October were sparsely distributed from Suisun Bay through the lower San Joaquin and Sacramento rivers and Delta, but common in the SDWSC. In November, the distribution contracted to the Sacramento River with a large number collected in the SDWSC (n = 503), and by December fish were distributed in the SDWSC and from the confluence downstream through San Pablo Bay.

Delta smelt

The delta smelt is a small (55-90 mm FL) osmerid endemic to the upper San Francisco Estuary. The delta smelt population declined dramatically in the 1980s and it was listed as a state and federal threatened species in 1993. This species is considered environmentally sensitive because it typically lives for one year, has a limited diet, and resides primarily in the interface between salt and fresh water. In addition, females have low fecundity and produce on average 1,200 to 2,600 eggs (Moyle et al. 1992).

The 2010 20mm Survey delta smelt index was 1.7 times the 2009 index (Figure 7A). The 2010 index is the fourth lowest index on record and consistent with the low indices of the last 4 years. The 20mm Survey began in March with delta smelt larvae present in the lower Sacramento River and Cache Slough. By the end of April, delta smelt catches were highest in the SDWSC and Cache Slough, with some caught in the confluence, Suisun Bay and to a lesser extent in the south Delta. The pattern of larval delta smelt catch in May and June continued to follow the April trend, with the highest catches in the SDWSC and Cache Slough and expansion of catch to Montezuma Slough and Suisun Bay. However, by the end of the survey in July catch of delta smelt juveniles was restricted to the lower Sacramento River, the confluence, and Cache Slough.

The 2010 TNS age-0 delta smelt index was 2.7 times the 2009 index (Figure 7B). The 2010 index is still a small fraction of the majority of indices recorded for the Summer Townet Survey prior to 2005 and ranks as the sixth lowest index during the study period. Delta smelt catch fluctuated over the sampling season, with peaks every other sampling period in mid-June (n=39), mid-July (n=61) and mid-August (n=67) and lower catches in early July, late July, and late August catches that ranged from only 5 to 19 fish. Throughout June, July, and August, delta smelt catch was highest in Suisun Bay, and centered at a Honker Bay station. There was a concurrent low catch of delta smelt in the lower Sacramento River; and only 3 delta smelt were caught elsewhere.

The 2010 FMWT delta smelt index was 1.7 times the 2009 index and was the fifth lowest on record (Figure 7C). In September of 2010, delta smelt were collected from Suisun Bay through the SDWSC and Cache Slough. In October, delta smelt distribution was limited to the lower Sacramento River and SDWSC. No delta smelt were caught in November. In December, delta smelt were collected in Suisun Bay and in the lower Sacramento River and Cache Slough.

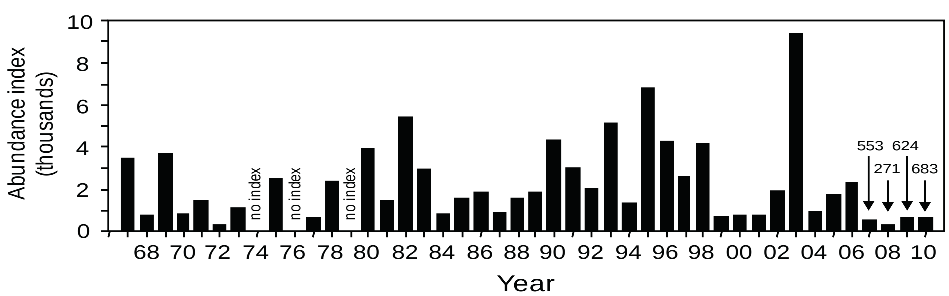

Figure 4 Annual abundance indices of American shad (all sizes) for the Fall Midwater Trawl Survey, September-December.

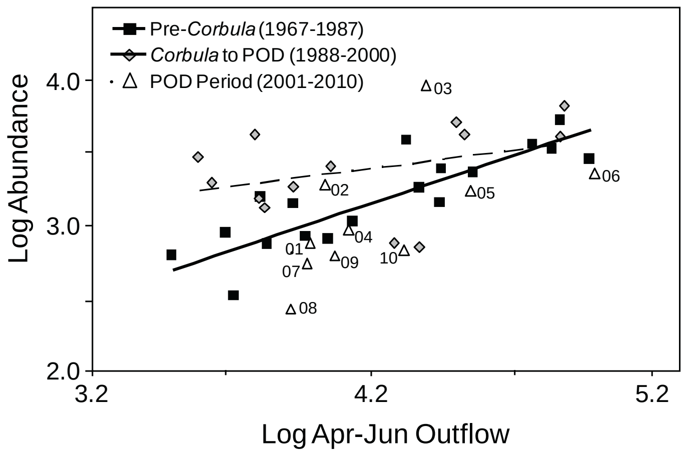

Figure 5 Fall Midwater Trawl Survey American shad (all ages) abundance index vs. average April through June outflow relationships pre-*Corbula amurensis* introduction (1967-1987; solid line), post-*Corbula amurensis* introduction (1988-2000; dashed line), and POD years (2001-2010; dotted line). Abundance and outflow data was $\log_{10}$ transformed.

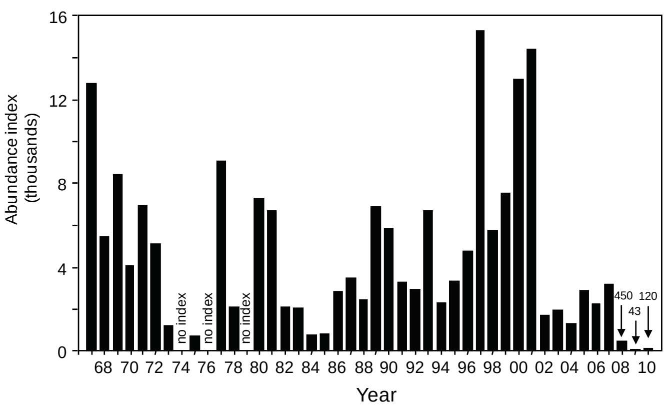

Figure 6 Annual abundance indices of threadfin shad (all sizes) for the Fall Midwater Trawl Survey, September-December.

Longfin smelt

The longfin smelt is a short-lived anadromous species that spawns in freshwater in winter and spring and rears primarily in brackish water. Some age-0 and age-1 fish migrate to the ocean in summer and fall, often returning to the estuary in late fall of the same year. A few longfin smelt mature at the end of their first year and most at the end of their second year, with some living to spawn or spawn again at age-3 (Wang 1986). A strong positive relationship between longfin smelt abundance and winter-spring outflow has long been observed (Stevens and Miller 1983). However, this relationship changed in the late 1980s, after the introduction of the overbite clam, *C. amurensis*. Although the slope of the outflow-abundance relationship did not change appreciably, longfin smelt abundance post-*C. amurensis* declined to a fraction of the pre-*C. amurensis* abundance (Sommer et al. 2007). This decline corresponded with a decline in phytoplankton and zooplankton abundance, which has been attributed to grazing by *C. amurensis* (Kimmerer 2002). A similar downward shift of the longfin smelt outflow-abundance relationship occurred after 2000, during the Pelagic Organism Decline years (Sommer et al. 2007, Fish et al. 2009).

The 2010 FMWT longfin smelt (all ages) index was 2.9 times the 2009 index and tied with the 2004 index as the seventh lowest on record (Figure 8). A few longfin smelt were caught each month from September through November in Suisun Bay, with 1 fish collected in San Pablo Bay in November. Almost all the catch occurred in December. Eight-eight percent of the total FMWT catch (n=85) occurred after water temperatures cooled. They were collected from San Pablo Bay through the Suisun Bay, with 1 fish collected in the lower Sacramento River.

The 2010 FMWT longfin smelt abundance index increased in response to the slightly higher winter/spring outflow than occurred in 2009. The FMWT longfin smelt abundance-outflow relationship shifted downward after the introduction of *C. amurensis* and again in the POD years, 2001-2010 (Figure 9). The 2010 index was slightly above the regression line for the post-*C. amurensis* abundance-outflow relationship. This year's increase in abundance may be attributed, in part, to the relatively strong 2008-year class, the parents of the 2010-year class. Mac Nally et al. (2010) described the FMWT longfin smelt abundance trend as a long-term decline punctuated by abundance increases associated with high outflow periods and they too detected that abundance was most significantly influenced by outflow.

The clam *C. amurensis,* through its affect on the food web, appears to have affected longfin smelt distribution. Longfin smelt distribution in the FMWT shifted towards higher salinity waters after 1989, a few years after *C. amurensis* was established (Figure 10). This suggests that *C. amurensis* displaced longfin smelt through a reduction in food availability, similar to that proposed for the northern anchovy (*Engraulis mordax*) distribution shift downstream reported by Kimmerer (2002). Longfin smelt diet once contained a high proportion of the mysid, *Neomysis mercedis* (Feyrer et al. 2003). The decline of *N. mercedis* also has been attributed to competition for food with *C. amurensis* (Kimmerer and Orsi 1996). One study found that *Neomysis* spp. primarily fed on diatoms, rotifers, and copepods (Siegfried and Kopache 1980), food resources shared with *C. amurensis* (Kimmerer and Orsi 1996). Longfin smelt may have relocated to higher salinity areas to find food sources not impacted by *C. amurensis*.

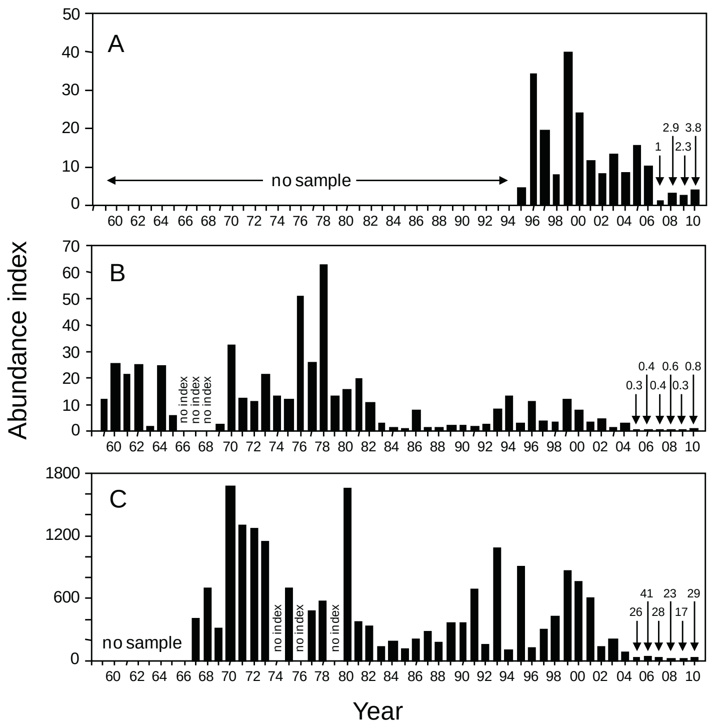

Figure 7 Annual abundance indices of delta smelt: A) 20mm Survey (larvae and juveniles); B) Summer Townet Survey (juveniles); C) Fall Midwater Trawl Survey (sub-adults).

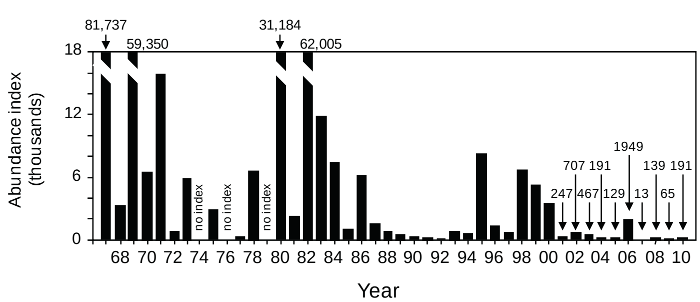

Figure 8 Annual abundance indices of longfin smelt (all sizes) for the Fall Midwater Trawl Survey, September-December.

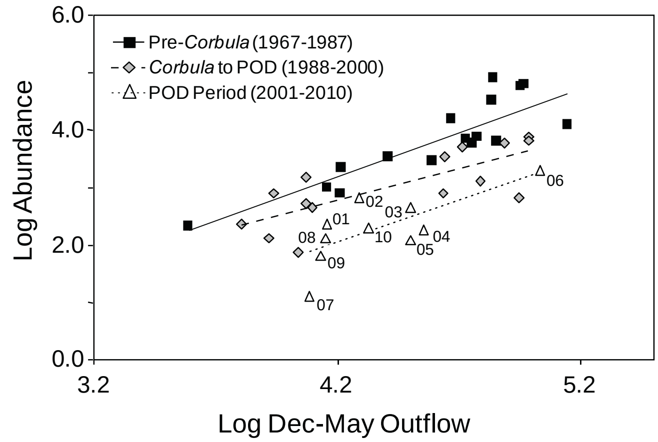

Figure 9 Fall Midwater Trawl Survey longfin smelt (all sizes) abundance index vs. mean December through May outflow relationships pre-*Corbula amurensis* introduction (1967-1987; solid line), post-*Corbula amurensis* introduction (1988-2000; dashed line), and POD years (2001-2010; dotted line). Abundance and outflow data was log_{10} transformed.

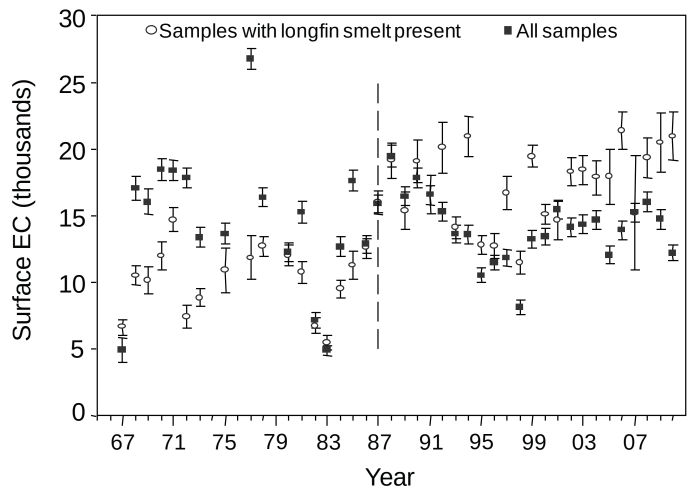

Figure 10 Fall Midwater Trawl Survey mean (±1 SD) surface water electrical conductivity (EC) for samples with longfin smelt present (open circles) and all samples (black squares). Dotted line represents the year *C. amurensis* was discovered.

Wakasagi

The wakasagi was purposely introduced as a bait fish into California lakes and reservoirs from Japan in 1959 (Wales 1962 and Dill and Cordone 1997). Wakasagi were not detected in the San Francisco Estuary until 1990, but may have been introduced as early as 1974 (Moyle et al. 1992). They are generally found in fresh water, but have higher salinity tolerances than delta smelt (Swanson et al. 2000). Wakasagi and delta smelt are typically planktivorous and reach maturity in a year (Moyle et al. 1992). Wakasagi catches are reported here as an update on their abundance and distribution, and to describe its distribution overlap with delta smelt.

Since TNS began in 1959, only 12 wakasagi have been caught at index stations, with 5 of those fish collected in 2009 (Table 1) in Suisun Bay, the confluence, and south Delta. With the addition of SDWSC stations in 2009, wakasagi were collected in the at a much higher frequency than elsewhere in the upper estuary. No wakasagi were caught in 2010 and the SDWSC was not sampled by the TNS.

Few wakasagi have been caught (n=36) by the FMWT survey. Prior to 2009, wakasagi were sporadically collected (n=12) in Grizzly Bay, Montezuma Slough, the lower Sacramento River, and Cache Slough. Similar to TNS in 2009, wakasagi were regularly collected in the SDWSC during 2009 and 2010 sampling (Tables 1 & 2).

For all years, wakasagi were generally found in salinities <0.5 ppt (n=31), but a few were also caught in salinities >7 ppt (n=5), and in temperatures ranging from 9.2ºC to 26.9ºC. The upper temperature observation is a higher temperature than delta smelt can tolerate (Swanson et al., 2000).

Table 1 Summer Townet Survey wakasagi catch per trawl from 1959 to 2010 (regions where no wakasagi were caught removed)

Year	Suisun Bay	Confluence	Lower Sac River	SDWSC	South Delta
1995	0.00	0.02	0.00	no sample	0.00
1996	0.00	0.04	0.03	no sample	0.00
1997	0.00	0.00	0.00	no sample	0.00
1998	0.00	0.00	0.00	no sample	0.01
1999	0.00	0.00	0.00	no sample	0.00
2000	0.00	0.02	0.02	no sample	0.00
2001	0.00	0.00	0.00	no sample	0.00
2002	0.00	0.00	0.00	no sample	0.00
2003	0.00	0.00	0.00	no sample	0.00
2004	0.00	0.00	0.00	no sample	0.00
2005	0.00	0.00	0.00	no sample	0.00
2006	0.00	0.00	0.00	no sample	0.00
2007	0.00	0.00	0.00	no sample	0.00
2008	0.00	0.00	0.00	no sample	0.00
2009	0.04	0.02	0.00	0.40	0.01
2010	0.00	0.00	0.00	no sample	0.00

Table 2 Fall Midwater Trawl Survey wakasagi catch per trawl from 1967 to 2010 (regions where no wakasagi were caught removed)

Year	Suisun Bay	Confluence	Lower Sac River	SDWSC	South Delta
1995	0.00	0.00	0.16	no sample	0.00
1996	0.04	0.00	0.00	no sample	0.00
1997	0.04	0.00	0.00	no sample	0.00
1998	0.00	0.00	0.00	no sample	0.00
1999	0.00	0.00	0.00	no sample	0.00
2000	0.00	0.00	0.16	no sample	0.00
2001	0.00	0.00	0.05	no sample	0.00
2002	0.00	0.00	0.00	no sample	0.00
2003	0.00	0.00	0.00	no sample	0.00
2004	0.00	0.00	0.00	no sample	0.00
2005	0.00	0.00	0.00	no sample	0.00
2006	0.00	0.00	0.00	no sample	0.00
2007	0.00	0.00	0.00	no sample	0.00
2008	0.00	0.00	0.00	no sample	0.00
2009	0.04	0.00	0.05	1.17	0.00
2010	0.00	0.00	0.05	1.60	0.00

Splittail

The splittail is endemic to the San Francisco Estuary and its watershed. Adults migrate upstream from tidal brackish and freshwater habitats during increased river flows from late fall through spring to forage and spawn on inundated floodplains and river margins (Sommer et al. 1997, Moyle et al. 2004). Such migrations are known to occur in the Sacramento, San Joaquin, Cosumnes, Napa and Petaluma rivers, as well as Butte Creek and other small tributaries. Most spawning takes place from March through May. Young disperse downstream as larvae, when river levels drop or as juveniles in late spring and early summer, when backwater and edge-water habitats diminish with reduced flows. Year-class strength is related to the timing and duration of floodplain inundation; moderate to large splittail year classes resulted from inundation periods of 30 days or more in the spring months (Sommer et al. 1997, Moyle et al. 2004).

Age-0 splittail may not be effectively sampled by long-term monitoring surveys employing trawling that requires fishing in open, moderately deep (≥ 2 m) water, because young splittail possess a strong affinity for shallow water. The USFWS Delta Juvenile Fish Monitoring Program conducts an annual beach seine survey and can calculate an abundance index for age-0 splittail. In addition to sampling along the shoreline, this survey samples throughout the Delta and upstream on the Sacramento River to Colusa and on the San Joaquin River almost to the Tuolumne River confluence (see methods), so it is able to detect recruitment upstream in the rivers, which becomes relatively more important as outflow declines.

The 2010 splittail age-0 beach seine index (USFWS data) was 4.2 times the 2009 index and the second highest index (Figure 11A). Seining captured good numbers of age-0 splittail in both the Sacramento and San Joaquin rivers in 2010. Both the highest and lowest abundances (in 2006 and in 2002, respectively) were recorded in the last 10 years. The variability of the age-0 splittail abundances likely reflects the variability in outflows in recent history.

The 2010 FMWT splittail (all ages) index was 0 (Figure 11B). This follows a 2009 index of 1 and 7 prior years of very low indices and reflects reduced use of the water column by splittail even though fall mysid numbers increased in 2010 and were relatively high in the early to mid-2000s (see Hennessy earlier in this issue).

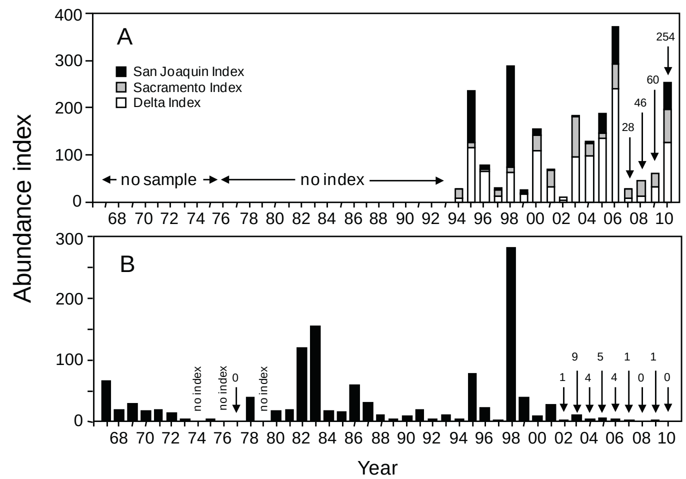

Figure 11 Annual abundance indices of splittail: A) USFWS beach seine (juveniles), May and June; B) Fall Midwater Trawl Survey (all sizes), September-December.

Striped bass

The striped bass is an anadromous fish first introduced to the San Francisco Estuary more than 125 years ago. Adult striped bass forage in the near-shore ocean and coastal bays and migrate up rivers to spawn in spring. Juveniles rear in fresh and brackish waters of the estuary. The population of legal-size fish in the San Francisco Estuary declined during the late 1970's and remained low until 1995 when it inexplicably increased, peaking in 2000 (Figure 12). Since the abundances for year 2004, 2005, and 2007 remain provisional, it is too early to tell if the decline observed after 2000 was interrupted by a brief increase (Figure 12). The most recent estimate is near a record low (Figure 12).

Age-0 striped bass abundance steadily declined after the mid-1980s. TNS and FMWT indices remained generally low in the late 1990s and early 2000s even though the adult population recovered modestly. Although the adult population exhibited a modest recovery, the fraction of females in the spawning run has been very low (~10%) since the early or late 1990s, depending on the data set examined (Jason DuBois, personal communication 2008). Such low female numbers could explain the low juvenile abundance indices. Stevens et al. (1985) hypothesized that low striped bass recruitment was related to: 1) the declining adult population, 2) reduced plankton food supply, 3) loss of large numbers of young striped bass to water diversions, and 4) population-level effects of contaminants.

Based on our understanding of factors controlling striped bass abundance in the estuary, the adult population increases leading to 2000 and in 2004 were unexpected and remain unexplained. Population modeling being conducted by UC Davis researchers in collaboration with IEP Biologists will allow examination of many of these issues.

The 2010 TNS age-0 striped bass 38.1-mm index was 1.9 times the 2009 index and tied with 2003 as the eighth lowest index on record (Figure 13A). Catch of striped bass juveniles peaked at over 300 fish in mid-June, then dropped over the course of the survey resulting in an end of survey late August catch of only 12 fish. In June, the majority of fish caught were in Suisun Bay, with the highest catches in Montezuma Slough. This trend continued throughout July, and August with most fish collected in Suisun Bay and a few fish collected in the confluence and lower Sacramento and San Joaquin rivers. Only 5 age-0 striped bass were caught in the south Delta sampling area during the course of the survey.

The 2010 FMWT age-0 striped bass index decreased to 61% of the 2009 index. This is the lowest index on record and consistent with the low indices seen since 2002 (Figure 13B). They were collected in Suisun Bay in all months. Catches were highest in September and November. In September, age-0 striped bass were caught from San Pablo Bay through the SDWSC, however this wide distribution is represented by merely 10 fish. In October, they were caught in Suisun Bay and SDWSC. By November, age-0 striped bass were caught in Suisun Bay and the south Delta. In December, striped bass were caught from San Pablo Bay through Suisun Bay.

Overall, pelagic fish abundances increased slightly in 2010, but remained at very low levels, striped bass was an exception showing a decline in fall, even though it exhibited a slight increase based on summer sampling by the TNS. These increases were most likely attributed to a slight outflow increase in 2010 compared to recent years (see Delta Water Operations, Water Year 2010 Annual Summary, Shahcheraghi and Chu earlier in this issue). FMWT sampling expanded into the Sacramento Deepwater Ship Channel and Cache Slough in 2009 and 2010 to assess fish use in general and delta smelt use in particular. In both years, FMWT caught delta smelt in low densities in the SDWSC in September and October, and a modest catch of 7 in upper Cache Slough in December 2010. Delta smelt were likely present in November and December of both years (temperatures peaked in September prior to last detection in October), but not always detected due to low densities. These non-index stations also produced relatively high catches of American shad (30-40 per tow on the high end) and threadfin shad (100 to 400+ on the high end), and wakasagi were regularly caught (2-3 per month). Thus, these SDWSC and Cache Slough stations appear to provide year-round habitat for delta smelt and other pelagic fish species. The FMWT will continue sampling these SDWSC and Cache Slough stations in the future and TNS will begin sampling them in 2011.

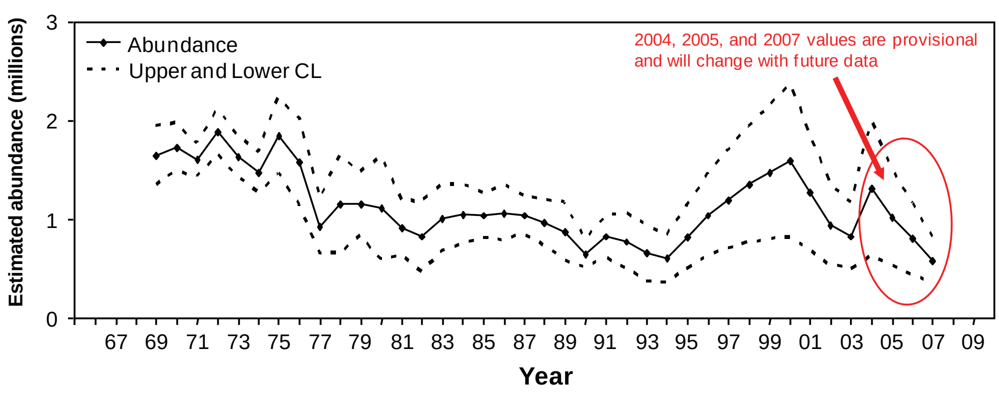

Figure 12 Estimated Abundance of Striped Bass Age ≥ 3 in the San Francisco Estuary from DFG Mark-Recapture Data. Note: values for 1995, 1997, 1999, 2001, and 2006 are mean of estimates from the immediate previous and following year.

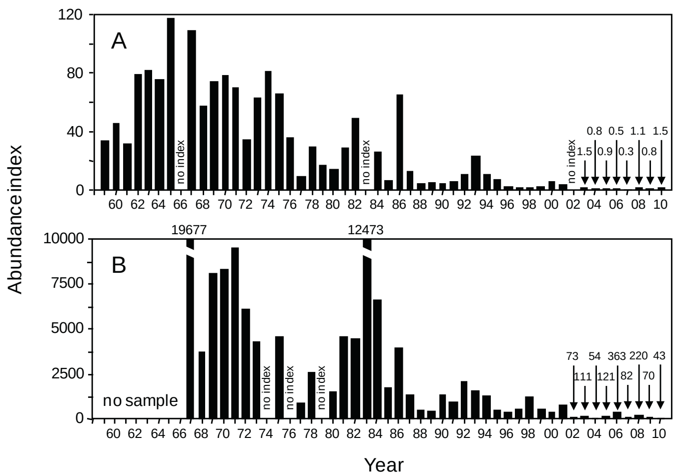

Figure 13 Annual abundance indices of age-0 striped bass: A) TNS 38.1-mm index; B) Fall Midwater Trawl Survey, September-December.

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Notes

Dayflow data from water.ca.gov/dayflow/

Jason DuBois, California Department of Fish and Game, email October 3, 2008.

Juvenile Salmonid Emigration Monitoring in the Sacramento River at Knights Landing

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Introduction

Juvenile anadromous salmonid emigration is being monitored on the Sacramento River near the town of Knights Landing (RM 89.5) for the 15th consecutive year (Snider and Titus, 1998) using paired 8' rotary screw traps anchored in the river. Current monitoring began October 1, 2010 and is scheduled to continue until June 30, 2011. The monitoring is conducted to develop information on timing, composition (race and species), and relative abundance of juvenile Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead trout (*Oncorhynchus mykiss*) emigrating from the upper Sacramento River to the Delta. The location at Knights Landing is upstream from the influence of fish produced in the Feather and American Rivers so all salmonids collected are assumed to originate from the upper Sacramento River system. During high flow events, above 23,000 cfs, the Tisdale Weir, located above Knights Landing will spill and divert water into the Sutter Bypass, part of the flood control system for the city of Sacramento. During these events, some juvenile salmonids will emigrate down the bypass and not be seen at the screw traps. The information collected at this sampling site is provided daily to fishery and water managers, providing an early warning for the presence of emigrating threatened and endangered salmon, particularly spring- and winter-run Chinook, heading into the Delta. This warning allows for implementation of management strategies such as closing the Delta Cross Channel gates to keep Sacramento fish out of the central Delta and the reduction of water exports to limit salmonid entrainment. The object of this report is to summarize results from October 1, 2010 to April 22, 2011.

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For information about the Interagency Ecological Program, log on to our website at http://www.iep.water.ca.gov. Readers are encouraged to submit brief articles or ideas for articles. Correspondence—including submissions for publication, requests for copies, and mailing list changes—should be addressed to Patricia Cornelius, California Department of Water Resources, P.O. Box 942836, Sacramento, CA, 94236-0001. Questions and submissions can also be sent by e-mail to:pcorn@water.ca.gov.

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